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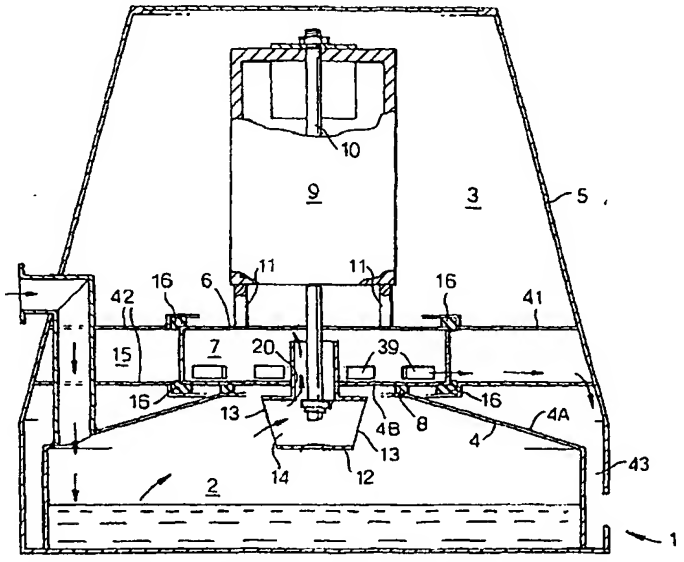
(54) Title: LIQUID BATH VACUUM CLEANER



(57) Abstract: A water bath vacuum cleaner (1) includes a water bath housing (2) and a fan enclosure (15) separated by wall (4). A fan assembly (7) is mounted within a fan housing (6) and is driven by a motor (9) to draw air from the water bath housing (2) through a separator (12). A small radial clearance (40) is provided between the rotating parts of a fan and separator assembly and the stationary parts of the fan housing (6). In order to prevent the passage of water droplets through the small radial clearance (40) the fan comprises at least two fan stages and is arranged such that the absolute air pressure within the fan housing (6) adjacent the small radial clearance (40) is higher than the absolute air pressure within the water bath housing (2). Accordingly, in use a small leakage of air occurs from the fan assembly back into the water bath housing, thereby preventing the passage of liquid droplets in the opposite direction.

LIQUID BATH VACUUM CLEANER

This invention relates to vacuum cleaners, and more particularly to vacuum cleaners of the water bath type.

In a water bath vacuum cleaner a water bath is employed for the purpose of removing dirt particles from air flowing through the vacuum cleaner. Typically, a fan is used to draw air into the vacuum cleaner and the air inlet to the vacuum cleaner is designed so that the in-flowing air is directed to a water bath. Dirt particles when they impinge on the water bath, will be retained and the air is withdrawn from the water bath housing to be discharged to the exterior of the vacuum cleaner.

In a self-contained water bath vacuum cleaner a motor driven fan is contained within the vacuum cleaner case to create the required flow of air through the vacuum cleaner. Typically, the water bath housing of the vacuum cleaner is closed by top wall having an aperture therein. The fan and fan motor are located above the aperture in a fan enclosure. The fan is designed to draw air through the aperture and thereby create a partial vacuum within the water bath housing. Means in the form of a water separator are provided for preventing water droplets being drawn into the fan. A typical prior art water bath vacuum cleaner of this type is shown in my prior United Kingdom patent publication GB-A-2338174.

The separator used to prevent water droplets being drawn into the fan is typically in the form of a rotating spinner coupled to the fan rotor. The spinner includes blades around the periphery thereof, the spaces between the blades defining flow passages for air passing from the water bath housing through the spinner into the fan. Because the separator is rotated at high speed in use of the vacuum cleaner water droplets or dirt particles entrained with the air leaving the water bath housing will typically impinge on the blades and be thrown radially outwardly. By this means, water and dirt particles are prevented from flowing through the separator into the fan. It will be appreciated, however, that because the fan is located within the fan

enclosure and the separator is located within the water bath housing, the connection between the fan and the separator must pass through the aperture in the wall that separates the fan enclosure from the water bath housing. In order to prevent water droplets in particular (and to some extent dirt) from bypassing the separator and flowing around the edge of the separator through the aperture from the water bath housing to the fan enclosure, some means must be provided at the wall separating the fan enclosure from the water bath housing for preventing the passage of water droplets. In the prior art, efforts are being made to prevent passage of water droplets through the clearance space between the wall and the separator by the mechanical design of the various components to minimise the running clearance and to shield the resultant gap from water droplets.

I have now devised an improved arrangement for preventing the flow of water droplets from the water bath housing into the fan enclosure.

In accordance with a first aspect of the present invention a water bath vacuum cleaner comprises a water bath housing and a fan enclosure separated by a wall having an aperture therein; a fan and separator assembly comprising a fan housing, a fan located within the fan housing for drawing air through the aperture, and a separator located within the water bath housing for separating liquid droplets from the air flow drawn through the aperture by the fan; and a clearance space between the fan and separator assembly and the wall, the air flow through the fan being arranged to provide a higher air pressure on the fan enclosure side of the clearance space than that which is present on the water bath housing side of the clearance space.

By arranging the fan to provide a higher pressure on the fan housing side of the clearance space than is present on the water bath housing side of the clearance space there will, in use, be a constant leakage of air from the fan enclosure into the water bath housing via the clearance space. Whilst this constant leakage of air will, to an extent, reduce the efficiency of the vacuum cleaner (in terms of the sub-ambient pressure which can be produced within the water bath housing by the fan), the constant flow of air will also have the effect of totally preventing the passage of water

droplets through the clearance space. By appropriate control of the dimensions the volume of air flowing through the clearance space can be kept to an acceptably low level and the advantages of the prevention of water droplets entering the fan housing will more than compensate for the disadvantage of the relative loss of efficiency resulting from the air flow through the clearance space.

Preferably, the fan is a multi-stage radial flow fan and is arranged such that the first stage is at the side of the fan remote from the water bath housing whilst the last stage of the fan is at the side of the fan adjacent the water bath housing. The effect of this arrangement is to ensure that the pressure present in the portion of the fan adjacent the wall is higher than the pressure which is present within the water bath housing.

Preferably, the fan is a two-stage fan comprising a first fan impeller located at the end of the fan remote from the water bath housing, a second fan impeller mounted at the end of the fan adjacent the water bath housing, and a diverter secured to the fan housing and extending between the first and second impellers. In such a case, the flow path from the aperture will initially be along the axial direction of the fan away from the water bath housing, then radially outwardly through the first fan impeller, then radially inwardly through the diverter, and then radially outwardly through the second fan impeller.

Further fan stages may be provided if a higher level of vacuum within the water bath housing is required.

Preferably, air is discharged from the fan housing through the radially outer wall of the fan housing.

In my prior United Kingdom patent GB-A-2338174 the separator was supported, at the end thereof remote from the fan, by means of a bearing mounted on a spider secured to the wall which separates the water bath housing and the fan enclosure. Such an arrangement is disadvantageous in terms of manufacturing complexity. Also, the bearing is subject to the action of the water and dirt contained within the water bath housing, which is undesirable.

According to a second aspect of the present invention there is provided a means for securing the separator to the fan motor which obviates the requirement for a bearing located at the free end of the separator.

In accordance with the second aspect of the present invention the fan assembly comprises a fan housing which includes a central hub which extends axially through the fan assembly from the end of the fan assembly remote from the water bath housing, to a distal region located adjacent the wall which separates the water bath housing from the fan enclosure, and the shaft of the motor which drives the fan and separator assembly is supported by a bearing mounted on the fan housing in the distal region.

By this means, the motor shaft can be fully supported at a point centrally of the fan and separator assembly, adjacent the wall which separates the water bath housing from the fan enclosure.

Preferably, the distal region is located on the water bath housing side of the wall. By supporting the motor shaft at this point no separate support bearing for the separator located at the free end of the shaft is required.

Preferably, both the fan and the separator are secured to the motor shaft at a point adjacent the distal region. Preferably, the fan includes a chassis which is supported on the hub by means of the bearing in the distal region and a further bearing located on the hub at the end thereof remote from the water bath housing. Preferably, the separator is secured to the fan chassis. In a particularly preferred embodiment of the invention the fan chassis is locked to the motor shaft by a first nut which runs on the motor shaft and the separator is locked to the fan chassis by a second nut which runs on the first nut.

The invention will be better understood from the following description of a preferred embodiment thereof, given by way of example only, reference being had to the accompanying drawings wherein:

Figure 1 is a schematic cross-sectional drawing of a water bath vacuum cleaner in accordance with the first embodiment of the present invention; and

Figure 2 is a detailed view of the fan housing and bearing arrangements of the vacuum cleaner of Figure 1.

Referring firstly to Figure 1, the vacuum cleaner 1 is of the water bath type and includes a water bath housing 2 and a fan enclosure 15 separated by a wall 4. The wall includes a radially outer portion 4A which is secured at the radially outer edges thereof to the casing 5 of the vacuum cleaner, and a radially inner portion 4B which is formed by part of the housing 6 of a fan assembly 7. A seal 8 is located between the wall parts 4A and 4B to prevent the passage of air or water therebetween.

An electric motor 9 is located within a motor enclosure 3 and includes an output shaft 10 which extends through the fan assembly 7. The motor 9 is mounted by means of pillars 11 on the fan housing 6, and the fan enclosure 15 is separated from the motor enclosure 3 by a wall 41. A separator 12 is secured to the motor shaft 10 and is located within the water bath housing 2. The separator includes air inlets 13 in ...cumferential wall thereof to allow air to pass from the water bath housing into the fan assembly. The air inlets 13 are separated by blades 14 so that as the separator rotates in use water droplets entrained with air entering the inlets 13 impinge on the blades and are thrown radially outwardly to be retained within the water bath housing 2.

The entire assembly of the motor 9, fan 7 and separator 12 is located within the main casing 5 on a support 42 by rubber mountings 16. The support 42 includes the wall 41 which separates the motor enclosure 3 and the fan enclosure 15. It will be noted that the assembly of the motor 9, fan 7 and separator 12 is self-contained and can be pre-assembled prior to mounting within the main casing 5.

Referring now to Figure 2, the components of the fan assembly 7 are shown in greater detail. It will be noted that the fan housing 6 includes a hub 17 which extends from the side 18 of the fan nearest the motor, towards the water bath housing, to terminate in a distal region 19. The distal region is located adjacent the aperture 20 which is formed in the centre of the wall part 4B of the wall 4. In the preferred embodiment, the distal region 19 is in fact on the side of the wall 4 remote from the

motor 9 – i.e. it is on the water bath housing side of the wall 4.

The motor shaft 10 is supported at the distal region by a bearing 21. A further bearing 22 is mounted on the hub 17 adjacent the motor end 18 of the fan housing 6.

It will be noted that the fan housing 6 is closed at the lower end thereof by a plate 23 the inner regions of which constitute the wall part 4B. The plate 23 defines the aperture 20 which connects the water bath housing 2 to the fan enclosure 3.

A fan chassis 24 is secured to the motor shaft 10 by means of a nut 25 which clamps the fan chassis 24 against a spacer 25 which in turn engages the inner race of the bearing 21. The opposite end of the inner race of the bearing is supported against the shoulder 26 on the motor shaft. By tightening the nut 25 the fan chassis will be clamped to the motor shaft.

The fan chassis 24 is also supported on the bearing 22. A first radial impeller 27 is connected to the fan chassis. A spacer 28 connected to the first impeller extends axially towards the water bath housing and carries a second impeller 29. The end of the spacer 28 nearest the water bath housing is supported by an annular skirt 30 which forms part of a spider 31. The spider 31 is itself secured to the fan chassis 24 by means of a nut 32 which runs on the nut 25. The separator 12 is mounted on the spider 31. The nut 32 clamps the spider 31 to the fan chassis for rotation therewith.

A flow diverter 33 is secured to the fan housing 6 and extends between impellers 27, 29.

The fan chassis 24, spacer 25 and skirt 30 together form an annular passage 34 which extends from the spider to the inlet 35 of the first impeller. The spider includes passages 43 which connect the passage 34 to the interior of the separator 12. A small annular clearance space 40 is provided between the exterior surface of the skirt 30 and the edge of the wall part 4B which defines the aperture 20.

When the motor shaft is rotated the impellers 27 and 29, the spacer 28, the spider 31 and the separator 12 are all rotated and air is drawn through the inlets 13, through the spider 31, along the passage 34 to the inlet 35 of the first impeller. Air is then forced radially outwardly by the first impeller to a transfer chamber 36 from

which it passes via the diverter 33 radially inwardly to the inlet 37 of the second impeller 29. The air flows radially outwardly through the impeller 29 to a second transfer chamber 38 from which it exits the fan housing via apertures 39 (Figure 1). The chamber 38 also extends to one side of the clearance space 40 formed between the aperture 20 and the skirt 30. Because the chamber 38 is located at the outlet of the second stage impeller 29 the pressure within the chamber 38 will be relatively high and will, more particularly, be higher than the pressure within the water bath housing 2. As a result, there will, in use, be a constant flow of air from the chamber 38 through the space 40 into the water bath housing 2. This flow will prevent entry of water and dust particles from the water bath housing 2 into the fan enclosure 3 or the interior of the fan housing 6 via the clearance space 40.

The bulk of the air leaving the fan housing via the apertures 39 passes through one or more exit passages 43 to be discharged to the exterior of the vacuum cleaner.

CLAIMS:

1. A water bath vacuum cleaner comprising: a water bath housing; a fan enclosure separated from the water bath housing by a wall having an aperture therein; a fan and separator assembly comprising a fan housing, a fan located within the fan housing for drawing air through the aperture, and a separator located within the water bath housing for separating liquid droplets from the air flow drawn through the aperture by the fan; and a clearance space between the fan and separator assembly and the wall, the air flow through the fan being arranged to provide a higher air pressure on the fan enclosure side of the clearance space than that which is present on the water bath using side of the clearance space.

2. A water bath vacuum cleaner according to claim 1 wherein: the fan is a multi-stage radial flow fan and is arranged such that the first stage is at the side of the fan remote from the water bath housing whilst the last stage of the fan is at the side of the fan adjacent the water bath housing.

3. A water bath vacuum cleaner according to claim 2 wherein: the fan is a two-stage fan comprising a first fan impeller located at the end of the fan remote from the water bath housing, a second fan impeller located at the end of the fan adjacent the water bath housing; and wherein means are provided to connect the outlet of the first fan impeller to the inlet of the second fan impeller.

4. A water bath vacuum cleaner according to claim 3 wherein: the means for connecting the outlet of the first fan impeller to the inlet of the second impeller comprises a diverter secured to the fan housing and extending between the first and second impellers.

5. A water bath vacuum cleaner according to any of claims 2 to 4 comprising:

further fan stages to provide a high level of vacuum within the water bath housing.

6. A water bath vacuum cleaner according to any preceding claim wherein air is discharged from the fan housing through the radially outer wall of the fan housing.

7. A water bath vacuum cleaner according to any preceding claim wherein the fan housing includes a central hub which extends axially through the fan assembly from the end of the fan assembly remote from the water bath housing to a distal region located adjacent the wall which separates the water bath housing from the fan enclosure; and wherein the shaft of the motor which drives the fan and separator assembly is supported by a bearing mounted on the central hub in the distal region.

8. A water bath vacuum cleaner comprising: a water bath housing; a fan enclosure separated from the water bath housing by a wall having an aperture therein; a fan and separator assembly comprising a fan housing, a fan located within the fan housing for drawing air through the aperture, and a separator located within the water bath housing for separating liquid droplets from the air flow drawn through the aperture by the fan; and a clearance space between the fan and separator assembly and the wall, wherein the fan housing which includes a central hub which extends axially through the fan assembly from the end of the fan assembly remote from the water bath housing, to a distal region located adjacent the wall which separates the water bath housing from the fan enclosure, and wherein the shaft of the motor which drives the fan and separator assembly is supported by a bearing mounted on the fan housing in the distal region.

9. A water bath vacuum cleaner according to claim 7 or claim 8 wherein the distal region is located on the water bath housing side of the wall.

10. A water bath vacuum cleaner according to any of claims 7 to 9 wherein both

the fan and the separator are secured to the motor shaft at a point adjacent the distal region.

11. A water bath vacuum cleaner according to any of claims 7 to 10 wherein the fan includes a chassis which is supported on the hub by means of the bearing in the distal region and a further bearing located on the hub at the end thereof remote from the water bath housing.

12. A water bath vacuum cleaner according to any of claims 7 to 11 wherein, the separator is secured to the fan chassis.

Fig.1.

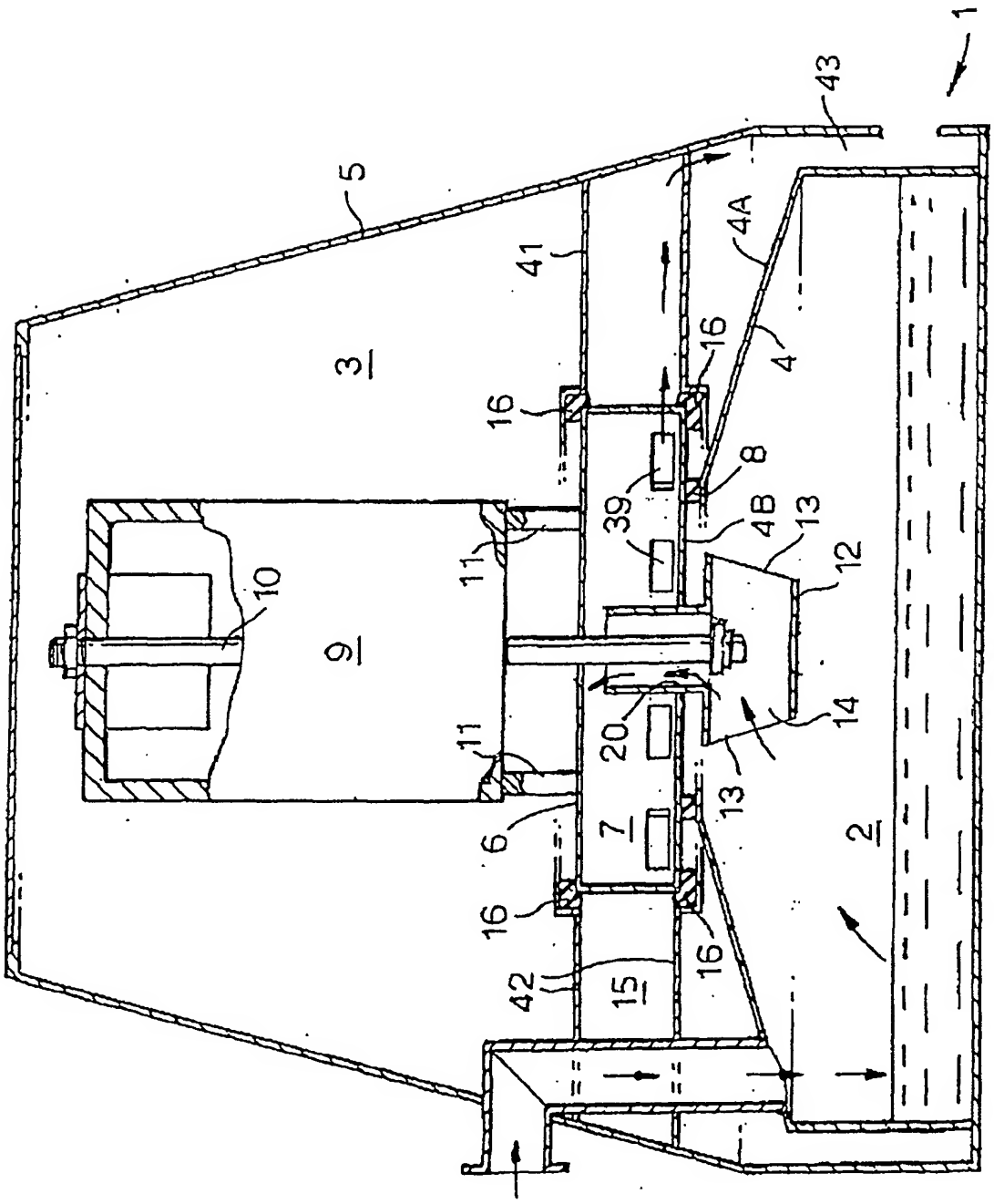
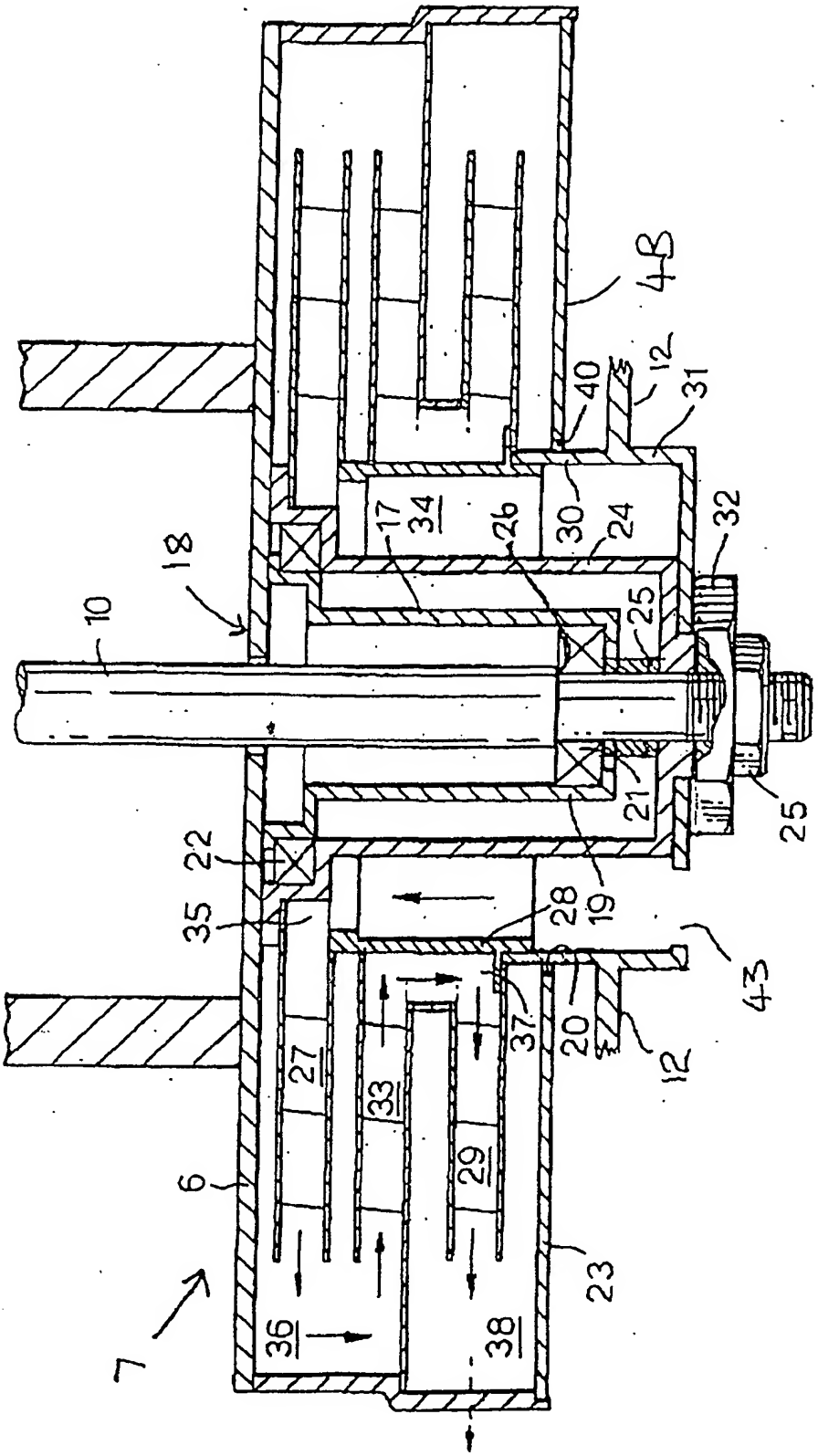


Fig.2.



INTERNATIONAL SEARCH REPORT

Int nal Application No
PCT/GB 01/02729

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A47L9/18 A47L9/22

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 338 174 A (THOMSON J P) 15 December 1999 (1999-12-15) cited in the application abstract page 3, paragraph 2 page 6, paragraph 3 figures	1,6
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A	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 04, 30 April 1997 (1997-04-30) -& JP 08 322770 A (AKAI ELECTRIC CO LTD), 10 December 1996 (1996-12-10) abstract figures	1,8
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
25 September 2001	02/10/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Cabral Matos, A

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 04, 30 April 1997 (1997-04-30) -& JP 08 317887 A (AKAI ELECTRIC CO LTD), 3 December 1996 (1996-12-03) abstract figures	1,8
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information on patent family members

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